(19) Canadian Intellectual Property Office

An Agency of Industry Canada

Office de la Propriété Intellectuelle du Canada

Un organisme d'Industrie Canada

(11) CA 2 443 871 (13) A1

(40) 02.10.2003

(43) 02.10.2003

(12)

(21) 2 443 871

(22) 02.04.2003

(51) Int. Cl.7: H04Q 7/36, H04L 12/46

(85) 19.09.2003

(86) PCT/KR03/000661

(87) WO03/084146

(30) 2002-18049 KR 02.04.2002

(71)
CHO, KWANG SUN,
#906 - 802 Zoogong Green Villa
Apt. 765 Gojan-dong
Ansan-shi
425-020, GYEONGGI-DO, XX (KR).

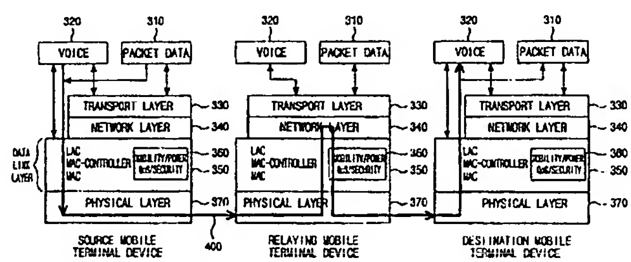
(72)
CHO, KWANG SUN (KR).

(74)
BULL, HOUSSER & TUPPER

(54) SYSTEME, APPAREIL ET METHODE DE COMMUNICATIONS MOBILES SANS FIL UTILISES CONJOINTEMENT AVEC UN SOUTIEN DE RESEAU AD HOC MOBILE

(54) SYSTEM, APPARATUS AND METHOD FOR WIRELESS MOBILE COMMUNICATIONS IN ASSOCIATION WITH MOBILE AD-HOC NETWORK SUPPORT

(57)
The present invention generally relates to a mobile communication technology combining with AD-HOC, and more specifically, to a mobile communication system configured to include a fixed communication facility for controlling communication between mobile terminal devices such as a transmission mobile terminal device, a reception mobile terminal device and other non-participation mobile terminal devices, and for mediating communication between the transmission mobile terminal device and the reception mobile terminal device. An AD-HOC network is formed between the mobile terminal devices, each device including a second frequency communication means for direct communication. When the AD-HOC network is formed between the transmission mobile terminal device, the reception mobile terminal device and other non-participation mobile terminal devices via the second frequency communication means, the transmission mobile terminal device can communicate with the reception mobile node via the AD-HOC network. Accordingly, the disclosed wireless mobile communication system can be effectively operated with reduced communication cost.



# SYSTEM, APPARATUS AND METHOD FOR WIRELESS MOBILE COMMUNICATIONS IN ASSOCIATION WITH MOBILE AD-HOC NETWORK SUPPORT

Description of corresponding document: **WO03084146** **Translate this text**

<Desc/Clms Page number 1>

SYSTEM, APPARATUS, AND METHOD FOR WIRELESS MOBILE COMMUNICATIONS IN ASSOCIATION WITH MOBILE AD-HOC NETWORK SUPPORT [Technical Field]
The present invention generally relates to wireless mobile communication technologies combining with an AD-HOC network support, and more specifically, to a mobile communication system configured to include an infrastructure-based communication facility, and to the system for communicating between mobile terminal devices via an AD-HOC network using a single or multi-hops when the same AD-HOC network is self-organized between a source mobile terminal device and a destination mobile terminal device.

[Background Art]
Various mobile communication services have been recently developed due to the pervasive use of wireless communication using mobile terminal devices such as a cellular phone, a PDA, and a laptop. However, a plurality of networks per mobile communication service overlaps each other in the same region, and each mobile communication service provides different communication cost, data transmission capacity, and connection conditions. As a result, when a user wants to connect with a plurality of mobile communication services if necessary, the user should have an extra mobile terminal device appropriate to each mobile communication service, and cannot connect with certain mobile communication service, in which is not supported by user's mobile terminal device. Although a terminal using a dual band (for example, supporting CDMA and GSM, or CDMA and WLAN) has been developing in order to solve the above-described problem, the terminal still should be selectively used in a region providing a specific mobile communication service.

The types of mobile communication services are classified into the basis of wireless communication service coverage as follows. First, a global layer is a mobile communication service having a wireless communication range of more than100km,

<Desc/Clms Page number 2>

such as satellite communication, in which it enables distant communication between areas, countries or continents. Second, a macro layer as a lower layer of the global layer has a cellular system having a wireless communication range of about 3km such as CDMA (Code Division Multiple Access), GSM (Global System for Mobile Communication), IMT-2000, W-CDMA, DVB (Digital Video Broadcasting), and DAB (Digital Audio Broadcasting), a wireless data transmission system having a wireless communication rangeof 2-5km such as LMDS (Local Multi-point Distribution Service), and a wireless data transmission system having a wireless communication range of about 30km such as MMDS (Multi-point Multi-channel Distribution Service). Next, a micro layer has a wireless communication range of about 300m such as WLAN (Wireless LAN) and HIPERLAN (High Performance Radio LAN). Finally, a pico layer as the lowest layer has a wireless communication range within 10m such as Bluetooth as WPAN (Wireless Personal Area Network), UWB (Ultra Wide-Band) or Wireless IEEE 1394.

Most mobile communication service exploits methods using an infrastructure- based communication facility and a network based on a single hop. On the other hand, an AD-HOC network self-organized by a plurality of mobile terminal devices is a communication method to self-form, self-maintain, and self-manage a network by providing a single hop or multi-hops without using an infrastructure-based communication facility and network.

Fig.1 is a conceptual diagram illustrating an AD-HOC network system. A source mobile terminal device 30 and a destination mobile terminal device 40 communicate each other using a single hop or multi-hops method wherein non- participation or relaying mobile terminal devices32,34, 36, and 38 route data. The

relaying mobile terminal devices do not participate directly in communication, but only relay data to its neighboring mobile terminal device located on the path to the destination mobile terminal device from the source mobile terminal one. Each mobile terminaldevice 30, 32, 34, 36, 38, and 40 itself reconstructs the changes of an AD-HOC network depending on the variations in terms of location of mobile terminal devices and on addition or removal of mobile terminal devices by exchanging routing information at any

<Desc/Clms Page number 3>

time. As a result, the mobile terminal devices can actively cope with any changes from communication conditions, secure stable communication by performing communication via other candidate routing path (s) when some mobile terminal devices perform faulty operations. Additionally, since the AD-HOC network does not communicate using an infrastructure-based communication facility, a communication network can be easily constructed with low cost. Owing to these advantages, the AD-HOC network has been primarily used for military communication, emergency communication, and a small- scale computer network.

Fig. 2 is a diagram illustrating a conventional wireless mobile communication network. The conventional mobile communication network performs communication via a fixed network infrastructure comprising a plurality of base stations 22,24, and 26, base station antennas established at each base station, a base station controller called BSC, a PCS exchanger PCX for controlling a plurality of base stations, and a mobile switching center MSC 20 including a home location register HLR maintaining location of subscribers.

The communication between subscribers is as follows. A source subscriber terminal 12 sets up communication with a first base station to which it belongs (102). A mobile communication exchange station 20 manages location of a destination subscriber terminal 14 registered at HLR to connect a second base station 26 to which the destination subscriber terminal 14 belongs via a wire network(106). The second base station 26 finally sets up communication with the destination subscriber terminal 14 (108). In other words, the process of setting up communication with the conventional wireless communication system is performing by control and mediation of the mobile communication exchange station 20 based on an infrastructure-based communication facility.

When the communication is performing using an infrastructure-based fixed communication facility, the following anticipated problems occur.

First, a mobile communication service provider has to establish a large amount of capacity with a plurality of base stations 22,24, and 26 in order to cover a wide area communication service. As a result, a subscriber bears high communication service

<Desc/Clms Page number 4>

charge due to facility investment cost and facility management cost paid by the service provider. Particularly, since an infrastructure-based fixed communication facility is used in all communications, a destination subscriber and a source subscriber should bear the same user's tariff regardless of distance even when they are located within a short distance.

Second, since all communications are performing by control and mediation of centralized and infrastructure-based fixed communication facilities given by service providers, a subscriber cannot receive communication service when the subscriber is out of a range of a base station.

Third, since service providers generally use infrastructure-based fixed communication facilities adopting heterogeneous protocols, a subscriber cannot receive communication service when the subscriber is out of a range of the corresponding service provider. For example, a subscriber using a CDMA terminal cannot receive communication service using his/her own terminal in a country adopting a GSM system.

Fourth, according to current mobile communication technology, in the aforementioned various mobile communication networks, a horizontal hand-off system is only admitted for supporting seamless communication during movement between base stations or access points (hereinafter, both are referred to as'connection node') of the same mobile communication networks depending on geographical movement. For example, when a wireless LAN user moves, a connection node in which the user currently connects with hands off traffic of the wireless LAN user into a new connection node if there are other connection nodes adjacent to the wireless LAN. However, when there are no connection nodes in a newly moved

region, the communication of the wireless LAN user is disconnected. Particularly, since the micro layer such as wireless LAN has a short wireless communication range, the number of connection nodes is considerably more required in the micro layer rather than in the macro layer. As a result, a wireless LAN service coverage of the user may be limited unless the large number of connection nodes is installed. When a wireless LAN user uses a cellular service as well as a wireless LAN service, in the case of no connection nodes for a wireless LAN service and connection nodes for a cellular network service, a vertical hand-off into the cellular

<Desc/Clms Page number 5>

network service during the use of the wireless LAN service is, in general, not supported.

[Detailed Description of the Invention]
The present invention proposed as a solution to solve the aforementioned problems has an object to provide a communication system, a communication method, and a mobile terminal device appropriate to the system and method which provides both of an inherent terminal function like a conventional mobile terminal device and of a relaying function in a mobile terminal device capable of self-organizing an AD-HOC network like an infrastructure-based fixed communication facility.

A preferred embodiment of the present invention has an object to provide a communication system, which may receive communication service by using the infrastructure-based fixed communication facility even when a mobile terminal device is out of a service coverage of the infrastructure-based fixed communication facility, a communication method, and a mobile terminal device appropriate to the system and the method.

Another preferred embodiment of the present invention has an object to provide a communication system, which may receive communication service by using the infrastructure-based fixed communication facility even in a service coverage of the infrastructure-based fixed communication facility providing different communication services, a communication method, and a mobile terminal device appropriate to the system and the method.

Still another preferred embodiment of the present invention has an object to provide a communication system, which can change a communication mode actively according to communication condition when mobile terminal devices communicate via anAD-HOC network, a communication method, and a mobile terminal device appropriate to the system and the method.

Still another preferred embodiment of the present invention has an object to provide a communication system wherein a vertical hand-off is possible between different wireless mobile communication networks using the common AD-HOC protocol, a communication method, and a mobile terminal device appropriate to the system and the

<Desc/Clms Page number 6>

method.

Still another preferred embodiment of the present invention has an object to provide a communication system, which can connect with a satellite ground station for communication with a satellite or VSAT, a bidirectional satellite terminal with small aperture, a communication method, and a mobile terminal device appropriate to the system and the method.

Still another preferred embodiment of the present invention has an object to provide a communication system wherein message can be effectively routed between different mobile communication networks by exploiting precise location information of a mobile terminal device from a GPS communication signal or a beacon signal received from an adjacent mobile terminal device, a communication method, and a mobile terminal device appropriate to the system and the method.

In order to achieve the above-described objects, there is provided an AD-HOC combined mobile communication system configured to include a source mobile terminal device, a destination mobile terminal device, other non-participation mobile terminal devices, and an infrastructure-based fixed communication facility for controlling communication among mobile terminal devices and for relaying communication between the source mobile terminal device and the destination mobile terminal device, wherein an AD-HOC network is self-organized among the mobile terminal devices, each device including a second frequency

communication means for direct communication; wherein the source mobile terminal device can communicate with the destination mobile terminal device via the AD-HOC network when the AD-HOC network is self-organized among the source mobile terminal device, the destination mobile terminal device, and other non- participation mobile terminal devices via the second frequency communication means for communication.

There is also provided an AD-HOC combined mobile communication device configured to be controlled by an infrastructure-based fixed communication facility and communicate with other mobile terminal device (s) via the infrastructure-based fixed communication facility, comprising: a first frequency communication means for communication via the infrastructure-based fixed communication facility; a second

<Desc/Clms Page number 7>

frequency communication means for transmitting and receiving data, a beacon signal, and routing information into other mobile terminal devices via an AD-HOC network; and a processor for controlling the communication device, wherein the processor includes: a beacon processing unit for detecting other mobile terminal device (s) within a range of the second frequency for self-organization of the AD-HOC network; a routing processing unit for generating its routing table dependent on the detection results from the beacon processing unit and routing information received from other mobile terminal devices; and a communication processing unit for activating the second frequency communication means when other mobile terminal devices for communication are included in the routing table, and for activating the first frequency communication means when they are not included in the routing table.

There is also provided an AD-HOC combined mobile communication method for performing communication between mobile terminal devices controlled by an infrastructure-based fixed communication facility via a first frequency, comprising: a first step wherein the mobile terminal device grasps other mobile terminal devices within a range of a second frequency; a second step wherein routing information is consecutively exchanged between the mobile terminal devices to generate a routing table, thereby self-organizing an AD-HOC network; and a third step wherein a source mobile terminal device communicates with the destination mobile terminal device via the AD- HOC network for self-organizing non-participation mobile terminal device (s) using the second frequency when a destination mobile terminal device wanting for communication exists in the routing table, and via the infrastructure-based fixed communication facility using the first frequency when the destination mobile terminal device does not exist in the routing table.

There is also provided an AD-HOC combined mobile terminal device configured to connect selectively with at least two or more ofa plurality of communication networks and communicate with other mobile terminal device via the communication network, comprising: a beacon processing unit for detecting other mobile terminal device within a range of the second frequency for self-organization of the AD- HOC network; a routing processing unit for generating its routing table dependent on the

<Desc/Clms Page number 8>

detection results from the beacon processing unit and routing information received from other mobile terminal devices or connection nodes to transmit the routing information into the other mobile terminal devices or the connection nodes at any time; a data processing unit for generating and processing data dependent on an AD-HOC protocol including the routing information; a communication network determination unit for grasping a usable network dependent on the routing table and determining a network to be used; and a communication unit for supporting communication with at least two or more of a plurality of different networks and AD-HOC communication with other mobile terminal devices.

There is also provided anAD-HOC combined mobile terminal device including a plurality of data link layers and physical layers which are connectable with one or more networks, comprising a MAC-controller sub-layer for selecting one of the plurality of data link layers and physical layers, including a MAC-controller header dependent on an AD-HOC communication protocol in a voice and/or data packet transmitted from an upper layer, and relaying voice and/or data packets received according to the AD-HOC protocol from other mobile terminal devices.

There is also provided an AD-HOC combined mobile communication system, comprising: at least two or more of a plurality of networks for connecting with mobile terminal devices via connection nodes, relaying voice and data communication of mobile terminal devices and routing data according to an AD-HOC protocol; and a mobile terminal device for directly connecting with connection nodes of at least two or more

of the networks and other mobile terminal devices to transmit or receive voice and/or data, selectively connecting with other mobile terminal devices or one of connection nodes of the networks according to communication protocols corresponding to each network during communication dependent on communication condition, and broadcasting its routing information to other mobile terminal devices and the connection nodes by updating a routing table related to other mobile terminal devices or the connection nodes connected at any time according to the AD-HOC protocol, wherein when the connected mobile terminal device connects with a second network from the currently communicating first network of the plurality of networks, the first network routes the

<Desc/Clms Page number 9>

voice and/or data packet (s) of the mobile terminal device into the second network.

There is also provided an AD-HOC combined mobile communication method, comprising: a first step of detecting a connectable network and an adjacent mobile terminal device to generate a routing table and determine a network to be connected; a second step of adding a MAC-controller header according to an AD-HOC protocol in a voice and/or data packet to be transmitted; a third step of connecting with the network via a physical layer connectable with the network determined in the first step, and connecting with other mobile terminal devices directly connectable with other adjacent mobile terminal devices when a mobile terminal device does not have a connectable network; a fourth step of continuously monitoring connection condition with the network connected in the third step or other mobile terminal devices, and renewing a routing table; and a fifth step of connecting other networks or other mobile terminal devices except the currently connected network or other mobile terminal network when the connection condition is proved to be inferior.

[Brief Description of the Drawings]
Fig.1 is a conceptual diagram illustrating anAD-HOC network.

Fig. 2 is a diagram illustrating a conventional mobile communication system.

Fig. 3 is a diagram illustrating an AD-HOC combined communication system according to a preferred embodiment of the present invention.

Fig. 4 is a diagram illustrating an AD-HOC combined mobile terminal device according to a preferred embodiment of the present invention.

Fig. 5 is a diagram illustrating protocol layers of each mobile terminal device according to a preferred embodiment of the present invention.

Fig. 6 is flow chart illustrating an AD-HOC communication method between a source mobile terminal device and a base station according to a preferred embodiment of the present invention.

Fig. 7 is a flow chart illustrating an AD-HOC communication method between a base station and a destination mobile terminal device according to a preferred embodiment of the present invention.

<Desc/Clms Page number 10>

Fig. 8 is a flow chart illustrating a method for detecting a mobile terminal device and exchanging routing information according to a preferred embodiment of the present invention.

Fig. 9 is a flow chart illustrating an AD-HOC communication mode converting method according to a preferred embodiment of the present invention.

Fig. 10 is a diagram illustrating an AD-HOC combined mobile communication network according to a preferred embodiment of the present invention.

Fig.11 is a diagram illustrating a structure of an AD-HOC combined mobile terminal device according to another preferred embodiment of the present invention.

Fig. 12 is a diagram illustrating communication protocol layers of an AD-HOC combined mobile terminal device according to another preferred embodiment of the present invention.

Fig. 13 is a flow chart illustrating a data packet processing method of a MAC- controller sub-layer of an AD-HOC combined mobile terminal device according to a preferred embodiment of the present invention.

Fig. 14 is a diagram illustrating a packet structure of a MAC-controller header of an AD-HOC combined mobile terminal device according to a preferred embodiment of the present invention.

Fig. 15 is a diagram illustrating a structure of an AD-HOC combined mobile communication system according to a preferred embodiment of the present invention.

Fig. 16 is a flow chart illustrating a communication method of anAD-HOC combined mobile terminal device according to another preferred embodiment of the present invention.

[Preferred Embodiments]
Fig. 3 is a diagram illustrating an AD-HOC combined communication system according to a preferred embodiment of the present invention. The AD-HOC combined communication system comprises infrastructure-based fixed communication facilities 20, 22,24 and 26 identical with conventional infrastructure-based fixed communication facilities such as CDMA, TDMA, GSM, GPRS, and IMT2000, and mobile terminal

<Desc/Clms Page number 11>

devices 32, 34, 35, 36, 37, 38,40, 42,44, and 46 which can self-organize an AD-HOC network.

Each mobile terminal device includes a second frequency communication means for direct communication by forming an AD-HOC network with other mobile terminal devices. Hereinafter, a first frequency communication refers to wireless communication using infrastructure-based fixed communication facilities, and the frequency used herein is a first frequency. A second frequency communication refers to an AD-HOC communication, and the frequency used herein is a second frequency.

Preferably, the second frequency is a licensed or unlicensed usable frequency such as ISM (Industrial, Scientific, and Medical) frequency of 2.4 GHz or U-NII (unlicensed national information infrastructure) frequency of 5 GHz. The unlicensed frequency refers to a frequency band used freely without extra license of wireless communication. The ISM frequency band is an unlicensed band for industry, science, and medical care using weak electric field strength. The U-NII frequency band is a freely used frequency which belongs to the U. S. unlicensed national information infrastructure for using wireless LAN.

When a source mobile terminal device 34 and a destination mobile terminal device 40 are self-organized in the same AD-HOC network, the source mobile terminal device 34 transmits its data into the destination mobile terminal device 40 by way of relaying mobile terminal devices35,36,37, and 38 which are not directly participated in communication by using multi-hops 112,114, 116, 118, and 120. Here, data need not be voice, and the data can include all types of data such as video data, message data, and multimedia data capable of transmitting in the form of a packet.

When the source mobile terminal device 34 and the destination mobile terminal device 40 are not included in the sameAD-HOC network, the mobile terminal devices can communicate via infrastructure-based fixed communication facilities 20,22, and 26 like the conventional communication system as shown in Fig. 2.

The source mobile terminal device 34 may not connect to the destination mobile terminal device 40 via the AD-HOC network and the infrastructure-based fixed communication facilities. Here, it is preferable that a first AD-HOC network can connect

<Desc/Clms Page number 12>

to a second AD-HOC network via an infrastructure-based fixed communication facility when the source mobile terminal device 34 and the destination mobile terminal device 40 are included in the first AD-HOC network and the second AD-HOC network, respectively. The advantage of the above-described communication system is represented when at least one of the source mobile terminal device 34 and the destination mobile terminal device 40 is out of communication service coverage or does not use a

communication system supported by infrastructure-based fixed communication facilities.

A case is exemplified when the source mobile terminal device 44 uses a CDMA system, the infrastructure-based fixed communication facilities and the destination mobile terminal device 40 use'a GSM system. When the source mobile terminal device 44 and the destination mobile terminal device 40 self-organize the same AD-HOC network, the source mobile terminal device 44 can communicate with the destination mobile terminal device 40 via the relaying mobile terminal devices34, 35, 36, 37, and 38 using the second frequency band. However, when they are not belonged to the same AD- HOC network, the source mobile device 44 communicates to the mobile terminal device34 using the GSM system among other mobile terminal devices 34 and 35 formed in the same AD-HOC network via the communication (103) with the second frequency band.

The mobile terminal device 34 routes its data to the base station 22 via the communication with the first frequency band (GSM) (102). The mobile communication exchange station 20 transmits its data from the base station 22 into the base station 26 where the destination mobile terminal device 40 is located (104,106). The base station 26 transmits its data into the destination mobile terminal device 40 via the communication using the first frequency band GSM (108), thereby setting up communications.

Next, when the source mobile terminal device 32 is out of coverage from the service area using the communication with the first frequency band, the same communication procedure is performed as described above except connection to the relaying mobile terminal device 34, which can connect with the base station 22, via the communication with the second frequency band (122).

The similar communication procedure is applicable when the destination mobile

<Desc/Clms Page number 13>

terminal device 46 uses communication protocols different from the source mobile terminal device 34 and the infrastructure-based fixed communication facilities. Since the source mobile terminaldevice 34 does not connect with the destination mobile terminal device 46 via the communication with the second frequency, it connects the base station 22 via the communication102 with the first frequency band. The mobile communication exchange station20 transmits data from the base station 22 into the base station 26 where the relaying mobile terminal device 40 is self-organized at the same AD-HOC network with the destination mobile terminal device 40 and uses the communication system (104, 106) with the same first frequency band. The base station 26 transmits data into the relaying mobile terminal device 40 via the communication with the first frequency band (108). The relaying mobile terminal device 40 transmits data into the destination mobile terminal device via the communication with the second frequency band (105), thereby setting up the communication.

When the destination mobile terminal device 42 is out of the service area using the first frequency communication band, the same communication procedure is applied as described above except connection to the destination mobile terminal device 42 via the communication with the second frequency of the relaying mobile terminal device 40 in the base station 26 (124).

As shown in the cases when the source mobile terminal device and the destination mobile terminal device use different communication systems, and the destination mobile terminal device is operating out of the service area, the above- described four cases can be preferably combined. More preferably, each base station 22, 24, and 26 can self-organize an AD-HOC network with mobile terminal devices by further comprising the second frequency communication means or receive routing information of mobile terminal devices within a cell via the communication with the second frequency.

The present invention can be applicable to wireless data communication service such as Bluetooth, wireless ATM or wireless LAN as well as mobile phone service such as cellular service or PCS service. Fig. 10 shows an example using wireless data communication. In the example using wireless data communication, system structure and

<Desc/Clms Page number 14>

operation procedures between system components are the same with the example using a mobile phone service ofFig. 3, but the structure of infrastructure-based fixed communication facilities is different. The infrastructure-based fixed communication facilities of the wireless data communication service are formed

as a plurality of access points 22', 24', and 26'covering an arbitrary certain area, routers 23,25, and 27, and a computer network 20'such as an Internet. The computer network 20'is connected with other routers23, 25, and 27 via coaxial lines or optical cables. The access point 22', 24', and 26'correspond to networks connected by the base stations 22,24, and 26 of Fig. 3, respectively. The routers 23,25, and 27 correspond to networks connected by base station controllers (not shown in Fig. 3), respectively. The computer network 20' corresponds to a network connected by the mobile communication exchange station 20.

The explanation of Fig. 10 will apply to that of Fig. 3 because the operation of the wireless data communication service is the same with the one of the mobile communication service.

Fig. 4 is a diagram illustrating an AD-HOC combined mobile terminal device according to a preferred embodiment of the present invention: The mobile terminal device is made of an antenna 200, a frequency synthesizing unit 210, encoder/decoder 222,224, 226, and 228, a base-band processor230, an I/O interface unit 250, an output unit 252, an input unit 254, and a memory unit 240. A mobile terminal device according to the present invention consists of a second modulator 216 and a second demodulator218 for the communication with a second frequency, a second encoder 226 and a second decoder 228, and a base-band processor230 including a routing processing unit234 and a beacon processing unit236, unlike the conventional mobile terminal device.

Since a frequency used in an AD-HOC communication is different from that for general mobile communication, the frequency synthesizing unit 210 further includes the second modulator 216 and the second demodulator 218. The AD-HOC communication may include the encoder 226 and the decoder228 different from the encoder 222 and the decoder 224 for the communication using the first frequency in order to obtain generality irrespective of communication protocols by services or communication options by countries.

<Desc/Clms Page number 15>

The base-band processor further includes the routing processing unit234 and the beacon processing unit 236 except functions provided in the conventional mobile terminal device. The beacon processing unit236 detects the existence of other mobile terminal devices within a range using a second frequency for self-organizing the AD- HOC network. The routing processing unit 234 generates and maintains a routing table including the shortest and the optimal path according to detection results from the beacon processing unit 236 and routing information received from other mobile terminal devices.

The communication processing unit 232 activates the second frequency communication means 216 and 218 when routing information of other mobile terminal devices wanting communication is included in its routing table, and activates the first frequency communication means 212 and 214 when it is not included in its routing table.

However, the beacon processing unit236, the routing processing unit 234, and the communication processing unit 232 are only categorized by functions. The actual functions may be implemented simultaneously in a processor embodied into a single chip or in parallel with a set of processors formed of separate chips.

Preferably, when mobile terminal devices cannot directly communicate with infrastructure-based fixed communication facilities 20,22, 24, and 26 via the communication means 212 and 214 using the first frequency band, the communication processing unit 232 adds routing control information in a packet data to be sent so as to be routed into other mobile terminal devices which can communicate directly with the infrastructure-based fixed communication facilities 20,22, 24, and 26 via thecommunication means 216 and 218 with the second frequency band.

Referring to Fig. 8, a process of generating a routing table is explained. The beacon processing unit236 periodically (S60) broadcasts a beacon signal to other mobile terminal devices via the communication means 216 and 218 (S20) using the second frequency band. The beacon processing unit236 receives an acknowledgement signal from other corresponding mobile terminal device (s) in response to the beacon signal(S30) and transfers the acknowledgement signal into the routing processing unit234. The routing processing unit234 combines the acknowledgement signal received from the beacon processing unit 236 with routing information received from other mobile terminal

<Desc/Clms Page number 16>

device (s) to update its routing table (S40). Then, the routing processing unit 234 broadcasts its newly updated routing information into other mobile terminal device (s) based on the routing table (S50).

Preferably, the routing table may contain a mobile terminal device identifier referencing to other mobile terminal devices, the number of hops, the amount of power dissipation, and location information. Here, the present invention further includes the power dissipation and location information as well as the information on the identifier and the number of hops contained in a routing table used for a general computer network.

Since the operating time of mobile terminal devices is constrained by the characteristic of using battery with limited power, when a mobile terminal device having much electric power consumption is used as a relaying mobile terminal device, communication can be unstable due to the excessive power consumption from the corresponding mobile terminal device in a short time. As a result, the amount of power dissipation and location information should be considered as important parameters in the design of a routing algorithm.

The mobile terminal device identifier may consist of more than two mapping information among a telephone number given to the mobile terminal device (or an electronic serial number given to the mobile terminal device), a MAC address, an IPv4 address, and an IPv6 address. When a telephone number is used as mapping information, the use of service is limited by different telephone number system of each country.

However, when a specific MAC address and an IP address are used, compatibility can be secured regardless of communication systems adopted between countries.

Preferably, in order to select an appropriate communication mode according to the amount of communication traffic in wireless data communication using the second frequency band, the communication processing unit 232 frequently checks the amount of transmitted and received data traffic, the contention degree for occupying channels with the use of the second frequency between each mobile terminal device, and the number of adjacent mobile terminal devices capable of communicating within a range of the second frequency band. Here, each mobile terminal device can change its communication mode into a centralized control communication mode when one of the individual information is

<Desc/Clms Page number 17>

proved to be higher than a threshold value, or into a distributed control communication mode when proved to be less than the threshold value.

The data communication is categorized into a distributed control mode or a contention mode, and a centralized mode or an allocation mode. The distributed control communication mode such as ALOHA or CSMA (Carrier Sense Multiple Access) attempts to exclusively occupy a shared channel using direct contention among mobile terminal devices, and solves a channel collision problem by a randomly back-off method.

Although the distributed control mode is based on the use of a simple protocol, it effectively uses a channel without packet delay when a traffic load is low. However, as the traffic load of the channel increases, collisions frequently occur and performance is considerably degraded due to the exponential increase of packet delay.

The centralized control as a communication mode using a scheduling algorithm based on one of slotted ALOHA, reservation ALOHA, PRMA (Packet Reservation Multiple Access), TDMA (Time division Multiple Access), reservation TDMA, polling, ISMA (Inhibit Sense Multiple Access) or Bluetooth provides a communication synchronization method using a method of allotting time slots to each node by reservation or polling. The centralized control mode can prevent collisions between packet transmissions because it allots its time slots to each mobile terminal device, and perform'a stable communication when an excessively high traffic load is given to a channel. However, when the traffic load is small, since the centralized control mode inevitably creates empty slots generated from the packet transmissions and packet delay resulting from the processing of the empty slots, it is less effective than the distributed control one.

According to a preferred embodiment of the present invention, the communication with the second frequency band between mobile terminal devices is performed by using the distributed control mode when the traffic load is small, and by using the centralized control mode when the traffic load is large, thereby maximizing efficiency of channel use. Fig. 9 shows a flow chart illustrating a communication mode converting process according to a preferred embodiment of the present invention. First, if a mobile terminal device is activated, the communication with the second frequency

<Desc/Clms Page number 18>

band is basically performed (S320) using the distributed control mode(S310). Here, as an initial mode, the centralized control mode may be opted. Next, the mobile terminal device frequently or periodically checks communication conditions including individual information such as the traffic of other mobile terminal devices with which it communicates, the contention degree for occupying the channel in order for each mobile terminal device to transmit and receive packets on a single channel using the second frequency, and the accessible number of adjacent mobile terminal devices via the communication with the second frequency(S330). Then, the mobile terminal device determines whether the current communication condition is more appropriate to the centralized control mode or to the distributed control one according to the checked condition information (S340). For example, the communication condition is determined using an individual decision condition such as a case when the traffic is proved to be more than a threshold value (S342), a case when the contention degree is proved to be more than a threshold value (S344) or a case when the connection node is proved to be more than a threshold value(S346). As a result, when the centralized control mode is appropriate, the centralized control mode is converted(S350), and when it is not appropriate, the distributed control mode is maintained(S360), thereby performing the communication with the second frequency(S320).

However, when the mobile terminal device communicates via the centralized control mode, a leader mobile terminal device like a server in a client/server system for allotting time slots to each mobile terminal device should be elected among mobile terminal devices. The chosen leader mobile terminal device should be existing at least one or more in the same AD-HOC network. The leader mobile terminal device is chosen from the cluster consisting of a mobile terminal device having the best power condition, a mobile terminal device having little variation in location, and a mobile terminal device having many connected neighboring mobile terminal devices within a service range using the second frequency. A leader mobile terminal device is chosen from the clusters of mobile terminal devices using at least one judgment method.

Fig. 5 is a diagram illustrating the hierarchical layer structure of protocols according to a preferred embodiment of the present invention.

<Desc/Clms Page number 19>

The protocol consists of application layers 310 and 320, a transport layer 330, a networklayer 340, a link layer350, and a physicallayer 370. The protocol of the present invention further includes a mobility/power/QoS/security management module 360 in addition to the network layer 340 and the link layer 350.

The application layers include programs for supporting a data communication 310 or a voice communication 320. The transport layer330 provides protocols such as TCP (Transmission Control Protocol) and UDP (User Datagram Protocol) supported in an Internet in order to set up a point-to-point communication. Here, QoS (Quality of Service) or a protocol for flow and congestion control is also provided in the transport layer 330.

The network layer 340 provides a protocol for routing packet data between source and destination mobile terminal devices via relaying mobile terminal device (s).

The link layer 350 provides a protocol for supporting reliable transmission and QoS according to the demand from higher layers, and includes LAC (Link Access Control), MAC (Media Access Control), a MAC-controller sub-layer, and a mobile/power/QoS/security management module. The LAC is a sub-layer for managing one-to-one communication or one-to-multiple communication between upper layers.

The MAC is a sub-layer which provides a protocol for managing service such as access support on a

communication medium to reliably transmit and receive various kinds of data, multiplexing and de-multiplexing of different data streams, correction of transmission error frames, and synchronization. The MAC-controller sub-layer is used to designate the MAC layer and the physical layer appropriately according to the first frequency communication using infrastructure-based fixed communication facilities or the second frequency communication using the AD-HOC network. Themobile/power/QoS/security management module 360 is used to manage various parameters necessary for routing and mapping information such as the above-described phone number (or a specific electronic serial number given to a corresponding mobile terminal device), an MAC address, and IP address. The physical layer 400 is a protocol for coding, modulating and encoding data transmitted from the upper layers into a type appropriate to communication.

<Desc/Clms Page number 20>

When the communication using the second frequency is performed via the AD- HOC network, data or voice of the application layers 310 and 320 in the source mobile terminal device is transmitted through the transportlayer 330, the network layer 340, the link layer 350 and the physical layer 370 into a relaying mobile terminal device (400).

Since the relaying mobile terminal device serves as a router for relaying data, when a packet for relay is input, the packet is transmitted into the destination mobile terminal device by only passing through the physical layer and the link layer into the mobile/power/QoS/security management module and the network layer without passing through the transport layer or the application layer. The destination mobile terminal device transfers its received data into the application layer because it only needs received data unlike the relaying mobile terminal device. Although a case when one relaying mobile terminal device for convenience is passing through is exemplified in Fig. 5, the same procedure of communication is performed when more than two relaying mobile terminal devices are interposed between the source mobile terminal device and the destination mobile terminal device.

The communication process of the present invention wherein communication between mobile terminal devices controlled by infrastructure-based fixed communication facilities using the communication with a first frequency is performing is as follows. In the first step, a mobile terminal device grasps locations of other mobile terminal devices within a service range of a second frequency. The method of finding mobile terminal devices'existence is performed by a method of broadcasting a beacon signal and replying an acknowledgement signal to its received beacon signal, as described above.

In the second step, routing information is consecutively exchanged between the mobile terminal devices to generate a routing table, thereby self-organizing an AD-HOC network. Although the routing method is similar to that of a conventional computer network, after the characteristic of mobile terminal devices using limited power source such as battery as described above is considered, it is preferable that information on power and location is contained in the routing table, and then routing is performed by a routing algorithm, reflecting from power and location conditions.

In the third step, a source mobile terminal device communicates with the

<Desc/Clms Page number 21>

destination mobile terminal device via the AD-HOC network for self-organizing a non- participation relaying mobile terminal devices using the second frequency when a destination mobile terminal device wanting for communication exists in the routing table, and via the infrastructure-based fixed communication facility using the first frequency when the destination mobile terminal device does not exist in the routing table. Here, when the source mobile terminal device can connect to the destination mobile terminal device by the AD-HOC network, the second frequency communication via the AD-HOC network is not primarily used, but the communication using the first frequency may be used according to selection of users.

Preferably, when the source mobile terminal device cannot communicate with the infrastructure-based fixed communication facilities, it can communicate with infrastructure-based fixed communication facilities by routing data into a mobile terminal device which can communicate with infrastructure-based fixed communication facilities among mobile terminal devices self-organized in the AD-HOC network.

Referring to Fig. 6 for detailed explanation, if the source mobile terminal device wants to transmit its

message to the destination mobile terminal device(S100), then the source mobile terminal device checks whether the destination mobile terminal device is included at its own routing table (S110). When it is included at the routing table, a non- participation mobile terminal device self-organized in the AD-HOC network using the communication with the second frequency as a relaying mobile terminal device (S120) routes its message from the source mobile terminal device into the destination mobile terminal device (S120), thereby setting up communication (S122).

When the destination mobile terminal device is not included in its routing table, in order to use the first frequency communication, the source mobile terminal device checks whether it can connect with the infrastructure-based fixed communication facilities such as set of base stations(S 130). When the source mobile terminal device can connects with the infrastructure-based fixed communication facilities, the infrastructure- based fixed communication facilities relay communication(S132) like a general mobile communication method, thereby setting up communication between the source and destination mobile terminal devices(S134).

<Desc/Clms Page number 22>

When the source mobile terminal device cannot communicate with the infrastructure-based fixed communication facilities because it is out of a service range of the communication with the first frequency or uses a different communication system from that of infrastructure-based fixed communication facilities, the source mobile terminal device determines whether there are other mobile terminal device (s) which can communicate with the infrastructure-based fixed communication facilities among other mobile terminal devices self-organized in the same AD-HOC network(S140). When there is no a mobile terminal device which can communicate with the infrastructure- based fixed communication facilities, the communication setting-ups are failed, and the communication is disconnected(S148). When there are relaying mobile terminal devices, the source mobile terminal device communicates with the base station via the relaying mobile terminal device (s), thereby setting up communication with the destination mobile terminal device (S 146) through the relaying of the infrastructure-based fixed communication facilities (S 144).

On the other hand, when the destination mobile terminal device cannot communicate with the infrastructure-based fixed communication facilities, a mobile terminal device, which can communicate with infrastructure-based fixed communication facilities among mobile terminal devices self-organized in the AD-HOC network including the destination mobile terminal device, receives data from the infrastructure- based fixed communication facilities and then route the data into the destination mobile terminal device. Referring to Fig. 7, if the destination mobile terminal device is designated to communicate with the source mobile terminal device(S200), the source mobile terminal device checks whether the destination mobile terminal device is included in its routing table (S210). When it is included in the routing table, data is routed to the destination mobile terminal device (S220) by using intermediate mobile terminal device (s) as relaying mobile terminal device (s) (S220) self-organized from the AD-HOC network via the communication with the second frequency.

When the destination mobile terminal device is not included in the routing table, the source mobile terminal device connects with the infrastructure-based fixed communication facilities via the communication with the first frequency(S230). The

<Desc/Clms Page number 23>

mobile switching center inquires a mobile terminal device's location into the location register system such as HLR, and determines whether the destination mobile terminal device is capable of connecting via the communication with the first frequency(S232) or not. When it is able to connect with the infrastructure-based fixed communication facilities, the communication between the source and the destination mobile terminal devices is set up(S234) like general mobile communication methods.

When the destination mobile terminal device is out of a service range of the first frequency communication service or does not communicate with the infrastructure-based fixed communication facilities because it uses a different communication system from the infrastructure-based fixed communication facilities, the mobile terminal device determines whether there are relaying mobile terminal devices which can communicate with the infrastructure-based fixed communication facility among other mobile terminal devices belonged to the AD-HOC network including the destination mobile terminal device (S240). When

there is no mobile terminal device which can communicate with the infrastructure-based fixed communication facility, the communication connection is failed, and the communication is disconnected (S246). When it proves that there exists a relaying mobile terminal device, the base station communicates with the destination mobile terminal device via the relaying mobile terminal device, thereby setting up the communication with the destination mobile terminal device (S244) through the relay of the infrastructure-based fixed communication facility and the relaying mobile terminal device(S242).

Fig. 11 is a diagram illustrating a structure of an AD-HOC combined mobile terminal device according to another preferred embodiment of the present invention. As shown in Fig. 11, the mobile terminal device according to the present invention comprises a central processing unit 1010, a communication network determination unit 1020, a plurality of communication units 1022,1024, and 1026, a memory unit 1040, an I/O interface unit 1050, an output unit 1052, and an input unit1054. Unlike the conventional mobile terminal device consisting of one communication unit, the mobile terminal device of the present invention includes at least two or more communication units 1022 and 1024, and an AD-HOC communication unit 1026. As a result, a mobile

<Desc/Clms Page number 24>

terminal device can selectively connect with at least two or more different communication networks, and directly communicate with other mobile terminal devices belonged to the AD-HOC network including a corresponding mobile terminal device.

The central processing unit 1010 converts input data received from a user into an appropriate type of voice and data, transmits it to the communication units 1022,1024, and 1026, converts a voice and/or data packet received from the communication units into an appropriate type to be outputted to a user, and controls each component inside the mobile terminal device. Particularly, the central processing unit 1010 includes a beacon processing unit 1016 necessary for AD-HOC communication. The beacon processing unit 1016 detects. accessible communication end-points within other networks or other mobile terminal devices within a range of a frequency used by the AD-HOC communication unit 1016 for the self-organization of the AD-HOC network. Each mobile terminal device having an AD-HOC communication function intermittently broadcasts a beacon signal to notify its information on location, residual power held at the mobile terminal device, degree of mobility. As a result, the dynamic connection conditions in the network can be fed back, thereby updating the routing table of the AD- HOC network, as described before.

Unlike the conventional AD-HOC mobile terminal device, the beacon processing unit 1016 of the present invention can detect either adjacent mobile terminal devices or connection nodes of the communicating network by receiving beacon signals from adjacent mobile terminal devices as well as the beacon signals broadcasting from each communication end-point capable of communicating to mobile terminal devices, where the communication end-point (hereinafter, referred to as connection node) can be corresponding to, for example, base stations in cellular networks or access points in wirelessLANs. Since the beacon signal is broadcast as the same frequency with the frequency allotted to the corresponding communication service, when the first frequency communication unit 1022 is capable of communicating with a cellular system and the second frequency communication unit 1024 with a wireless LAN system, the beacon processing unit1016 receives a beacon signal from a base station of the cellular system via the first frequency communication unit 1022, a beacon signal from a wireless access

<Desc/Clms Page number 25>

point via the second frequency communication unit 1024, and a beacon signal from an adjacent mobile terminal device via the AD-HOC communication unit 1026.

The central processing unit 1010 includes a routing processing unit 1014 for generating its routing table according to detection results of beacon signals from the beacon processing unit 1016, routing information received from other mobile terminal devices or connection nodes, and transmitting its routing information into the other mobile terminal devices or the connection nodes at any time. Like a generic AD-HOC terminal device, the mobile terminal device of the present invention including the routing processing unit 1014 renews its routing table according to the variations of connection condition in the dynamically changing AD-HOC network. The routing processing unit 1014 of the present invention enables a vertical hand-off between different communication systems by including information on location and connection possibility of connection nodes as well as adjacent mobile terminal devices, which can connect with a plurality of communication units consisting of the corresponding mobile terminal devices, in the routing table.

Preferably, the mobile terminal device further includes a memory unit 1040, thereby storing the routing table generated from the routing processing unit 1014 of a corresponding mobile terminal device into the memory unit 1040. The memory unit 1040 stores routing information transmitted from adjacent mobile terminal devices or connection nodes.

More preferably, in relation to the routing table, routing with each mobile terminal device can consider physical location relations as well as logical location relations. Since the physical location relations with the corresponding mobile terminal devices and adjacent mobile terminal devices or connection nodes are closely related to the amount of power dissipation required in transmission, the routing table contains location information of each mobile terminal device and connection nodes, thereby primarily considering the most adjacent mobile terminal device (s) or connection node (s) in the case of selection for a routing path or a communication system.

Two methods for generating location information in a corresponding mobile terminal device are disclosed in the present invention. The first method is to use a GPS

<Desc/Clms Page number 26>

receiving unit 1030, and the second method is to generate relative location relations by measuring the strength of the beacon signal received from the adjacent mobile terminal device (s) and the connection node (s). In the first method to use the GPS receiving unit 1030, the corresponding mobile terminal device further includes a GPS receiving unit1030 for receiving its current location as GPS information via a GPS satellite, and a GPS processing unit 1018 for converting the GPS information into location information appropriate to communication. As a result, the location information is added in a data packet transmitted via the communication units 1022,1024, and 1026, thereby transmitting its current location of the corresponding mobile terminal device into adjacent mobile terminal device (s) and connection node (s). Additionally, the corresponding mobile terminal device extracts the location information included in the data packet received from the adjacent mobile terminal device (s) or the connection node (s), and then maintains its location of the adjacent mobile terminal device (s) and the connection node (s), thereby generating a routing table.

In the second method to use a beacon signal, the beacon processing unit 1016 measures variations in the strength of beacon signals received from adjacent mobile terminal device (s) and connection node (s) using a radio triangulation method, thereby obtaining approximate location relations and speed of a corresponding mobile terminal device. Although an additional GPS receiving unit is not required in this method, an exact location coordinates cannot be obtained. However, when the absolute location information such as GPS information is included in a data packet received from one or more of the adjacent mobile terminal device (s) or the connection node (s), the approximate location can be inferred, based on the information.

The central processing unit 1010 includes a data processing unit 1012 for generating and processing data owing to an AD-HOC protocol based on a routing table.

Since voice and data packets of the communication units1022, 1024, and 1026 transmitted by the data processing unit 1012 are processed by the common AD-HOC protocol, even when the mobile terminal device is connected with a cellular system, the mobile terminal device can be handed off into a different network such as wireless LAN adaptively according to variation of networks or into an AD-HOC network via an

<Desc/Clms Page number 27>

adjacent mobile terminal device. The detailed explanation on the data packet according to the AD-HOC protocol will be given to the references of Figs.13 and 14.

The communication network determination unit 1020 determines communication network (s) to be communicated by maintaining available networks according to the routing table. Preferably, a user can designate a priority among a plurality of accessible networks. For example, when a mobile terminal device can connect with a cellular system and a wireless LAN system, the user can give a priority to the wireless LAN system which have low communication cost per packet. As a result, the communication network determination unit 1020 primarily determines a network to connect with the wireless system when the

mobile terminal device can connect with both of connection nodes (base stations) of the cellular system and connection nodes (access point) of the wireless LAN system in its current location. When it is proved that the mobile terminal device can connect with connection nodes of the wireless LAN system according to its location movement even during communication via the cellular system, the communication network determination unit 1020 controls the communication to be connect with the wireless LAN system without delay.

The communication units 1022,1024, and 1026 can support communication with at least two or more of a plurality of different networks and AD-HOC communication with other mobile terminal devices. When the first frequency communication unit 1022 is a cellular communication module and the second frequency communication unit 1024 is a wireless LAN communication module, if a communication module to be used by the communication network determination unit 1020 is decided, a signal processed as a base-band signal in the central processing unit 1010 is modulated using a method appropriate to each communication system, and transmitted into a connection node of a corresponding communication network. Here, the voice and/or data packet is the same when the first frequency communication unit is used or when the second frequency communication unit is used, but it is modulated into a signal appropriate to a chosen network. Although each communication unit is shown to consist of a separate antenna in Fig. 11, it is preferable that the antenna is combined to support a plurality of frequency communication such as smart antenna.

<Desc/Clms Page number 28>

In the preferred embodiment, the communication unit for supporting two different networks and the AD-HOC network is exemplified. However, the number of used networks is not necessarily limited in two different networks. The number of chosencommunication networks can be increased by using more than three frequency communication units. The first frequency communication unit and the second frequency communication unit can be implemented by communication modules used in heterogeneous networks. Preferably, the frequency communication units can be embodied by choosing at least two or more among WPAN such as Bluetooth, UWB, wireless IEEE 1394, WLAN such as IEEE 802.11, HIPER LAN, and versatile communications such as CDMA, GSM, cellular, DVB,DAB, WCDMA, CDMA2000, LMDS, MMDS, and satellite communication.

The I/O interface unit 1050 mediates data communication between the central processing unit 1010 and the output unit 1052 for outputting the received voice and/or data packet to a user or the input unit 1054 for receiving the input from the user. The input unit 1054 comprises input interfaces such as a microphone for receiving voice of the user or operation keys for receiving key inputs of the user. The output unit 1052 consists a speaker for outputting sound and a display for outputting message and image data.

Fig. 12 is a diagram illustrating an OSI (Open system Interconnection) layer model of the mobile terminal device according to another preferred embodiment of the present invention. As shown in Fig. 12, theAD-HOC combined mobile terminal device consists of a transport layer 1110, a network layer 1120, a data link layer (not shown), and a physical layer. However, unlike general communication equipment, the data link layer and the physical layer consist of a single MAC-controller sub-layer1130 at the data link layer, a plurality of MAC layers 1142,1144, and 1146, and physical layers 1152, 1154, and 1156 for the corresponding number of accessible communication networks.

The plurality of MAC layers correspond to the number of frequency communication units which enables to connect accessible networks with a single MAC-controller sub- layer1130, which is a sub-layer of the data link layer. The MAC-controller sub-layer1130 contains a mobility/power/QoS (Quality of Service)/security management module

<Desc/Clms Page number 29>

1132, thereby further including a MAC-controller header, in which it has header information related to mobility, power, service quality, connection and security, in a transmitted packet, and processing a received packet according to the header information related to mobility, power, service quality, connection and security of the transmitted packet. The data packet including the MAC-controller header is transferred into MAC and physical layers corresponding to a network determined by the communication network determination unit.

Fig. 13 is a flow chart illustrating a MAC-controller sub-layer of the AD-HOC combined mobile terminal device according to a preferred embodiment of the present invention. In a NSDU (Network Service Data Unit) transferred from a network layer, service processed by a service classifier of the MAC-controller sub-layer is primarily classified. In general, messages coming from higher layers are registered at a security/connection manager 1212 to manage its connections with data links. For this registration, a security-related process such as an authentication is performed in advance.

Next, voice and/or data packets are transmitted into a service scheduler 1220.

The service scheduler 1220 receives power information, location information, and buffer information of the corresponding voice and/or data packet from a power manager1223, a location manager 1222, and a buffer manager 1226, and includes a header related to the above information in the voice and/or data packet. When a mobile terminal devices directly communicate with an adjacent mobile terminal device via the AD-HOC network, the power information means information on the amount of power dissipation between the corresponding mobile terminal device and the adjacent mobile terminal device, and the current remaining amount of power of the corresponding mobile terminal device. The location information may be relative location information calculated by the beacon processing unit 1016 or by using GPS information received from the GPS processing unit1018 as information related to current location of the corresponding mobile terminal device or through variations in the size of the beacon signal received from the adjacent mobile terminal device. The buffer information for allotting available buffers to use in transmission or reception of the voice and/or data packet resolves a function of competing packets to transmit or receive in a plurality of communication units via a

<Desc/Clms Page number 30>

single mobile terminal device or of allotting or revoking buffers by service class for processing priority in order to satisfy quality objectives defined in quality of service (QoS) of a plurality of packets transmitted or received from the single communication unit.

A service forwarder unit 1230 forwards the voice and/or data packet which includes the MAC-controller header into MAC and physical layers determined by the communication network determination unit 1020 among a plurality of MAC layers via the above-described process or forwards the packet to be processed in network layers which are upper layers.

Fig. 14 is a diagram illustrating the structure of the MAC-controller header according to the present invention. When the voice and/or data packet including the MAC-controller header is received, the service classifier 1210 filters fields on a MAC- Con-msg-type and a service type, and classifies the fields according to a corresponding message type, thereby processing the voice and/or data packet. The security/connection manager 1212 performs authentication, encryption and other functionality for messages to be connected with by using fields on association id. , authentication, sequence number, timestamp, challenge, connection and connection state. The service scheduler 1220 allots buffers of inputted messages and manages information on power and location by using fields on Power info. , Location info., Signal info., Buffer size, Priority, Power map, Signal map, Location map, and Env (environmental) response. Additionally, the service scheduler 1220 includes a control and management function by containing data represented as simple control information as well as program code such as code type, code length, and code to be executed in a mobile terminal device when it receives the corresponding packet to provide optimal network support depending upon the dynamically changed network condition.

Fig. 15 is a diagram illustrating an AD-HOC combined multi-mobile communication system according to a preferred embodiment of the present invention.

The mobile communication system comprises a plurality of communication networks and a plurality of mobile terminal devices1300,1350, and1300'. Each communication network connects(1312, 1322) with the mobile terminal device1330 via connection

<Desc/Clms Page number 31>

nodes 1310 and1320, relays voice and data communication of the mobile terminal device 1300, and routes voice and data according to an AD-HOC protocol. For example, when the mobile terminal device1300 can connect with a cellular network and a wireless LAN network, then the connection nodes are the base station 1310 of the cellular network and the access point 1320 of the wireless LAN network. However, since

voice and data of the present invention transmitted and received between the mobile terminal device 1300 and the connection nodes1310 and 1320 are to be routed according to the AD-HOC protocol unlike the conventional communication system. The above voice and/or data, consists of power information, location information, and buffer information by further including the MAC-controller header.

The mobile terminal device 1300 can transmit and receive voice and/or data by directly connecting with other mobile terminal devices 1350 and at least two or more of connection nodes 1310 and 1320 of each communication network. The mobile terminal device is selectively connected with one of the connection nodes1310 and1320 of the network or other mobile terminal devices1350 according to a communication protocol corresponding to each network during communication dependent upon communication conditions. Additionally, the mobile terminal device renews its routing table related to the other mobile terminal device 1350 or the connection nodes 1310 and 1320 connectable at any time according to the AD-HOC protocol, and broadcasts its routing information into the connection nodes and the other mobile terminal devices. That is, the mobile terminal device1300 includes a MAC-controller header through a MAC- controller sub-layer according to the AD-HOC protocol as well as a data link header adapted to the corresponding communication network through a MAC layer corresponding to a chosen network, thereby transmitting data according to a frequency, a modulation, and a demodulation methods defined in a corresponding network through a physical layer corresponding to a chosen network.

When the communicating mobile terminal device 1300 is connected from the currently used first communication network to the second communication network in a plurality of networks, the first communication network routes voiceand/or data packets of the mobile terminal device1300 into the second communication network. When the

<Desc/Clms Page number 32>

mobile terminal device1300 moves from the area A to the area B of Fig. 5, it is connected with the first communication network in the area A (1312), and handed over to the second communication network in the area B(1322).

Preferably, the mobile terminal device1300 further includes a GPS receiving unit and broadcasts routing information further including its location information. When the voice and/or data is routed into the mobile terminal device 1300, the communication networks can transmit data through the connection nodes 1310 and 1320 adjacent to location information of the mobile terminal device into the mobile terminal device1300 or the other mobile terminal device 1350 self-organized in the AD-HOC network 1352 including the mobile terminal device 1300, as described before.

According to another preferred embodiment of the present invention, the mobile terminal device. 1300 connects with a satellite communication network, thereby extending its communication service range. A low earth orbit satellite or a medium earth orbit satellite can communicate with a portable mobile terminal device on earth.

However, for communication with a geostationary orbit satellite, the distance between a satellite and a wireless mobile terminal device increases. As a result, a high output power is required, thereby causing limits in actual design of the mobile terminal device.

Accordingly, the communication between a ground station1330 and the AD-HOC network is more preferably used than the direct communication with the satellite 1340.

For example, when a WLAN system is used for a means of the AD-HOC communication, the mobile terminal device1300 should be connected with a WLAN communication network. The ground station1330 communicates with a WLAN connection node via an Ethernet port. As a result, the mobile terminal device1300 cancommunicate with the ground station1330, thereby directly communicating with the mobile terminal device1300'via the ground station 1330'located in a remote place through the satellite 1340.

When the mobile terminal device 1300 communicates(1332)'with the ground station 1330 using the AD-HOC network, a MAC-controller sub-layer according to the AD-HOC communication is further included in the ground station. As a result, the AD- HOC network is self-organized with the mobile terminal device1300 and the ground station, thereby enabling communication.

<Desc/Clms Page number 33>

Fig. 16 is a flow chart illustrating acommunication method of an AD-HOC combined mobile terminal device according to another preferred embodiment of the present invention. In the first step, the mobile terminal device detects a connectable network and an adjacent mobile terminal device to generate a routing table, and determine a network to be connected (1510). The detection of the network and the mobile terminal device is performed by receiving a beacon signal from the connection nodes1310 and 1320 of the network and the adjacent mobile terminal device 1350.

In the second step, a MAC-controller header according to an AD-HOC protocol is added in a voice and/or data packet to be transmitted (1.520). The MAC-controller header enhances efficiency of routing by containing power information, location information and buffer information.

Next, the mobile terminal device connects with a corresponding communication network via a physical layer connectable with the network determined in the first step (1540). When there is no connectable network, in the third step, the mobile terminal device connects (1550) with the other mobile terminal device via an AD-HOC physical layer directly connectable with other adjacent mobile terminal device (1350).

In the fourth step, the mobile terminal device continuously monitors connection condition with the network connected in the third step or other mobile terminal devices, and renewing a routing table (1542,1552). The detection of connection conditions is performed using a method similar to the conventional mobile communication. The renewal of the routing table prepares expected variations of networks resulting from location and power changes of the corresponding mobile terminal device 1300 and the adjacent mobile terminal device 1350.

In the fifth step, the mobile terminal device connects with other networks or other mobile terminal devices except the currently connected network or other mobile terminal network when the connection condition is proved to be inferior (1544,1554).

More preferably, the first step further comprises the sub-step of inputting priority into a plurality of networks with which the mobile terminal device can connect, wherein when a plurality of connectable networks are competing in network determination of the first step and network change of the fifth step, a network is

<Desc/Clms Page number 34>

determined or changed according to the priority. For example, referring to Figs. 4 and 11, the mobile terminal device is located in the area C capable of connecting with both of the first network and the second network, a user can set up communication so that the mobile terminal device may primarily communicate with the network which the user inputs connection priority.

[Industrial Applicability]
As discussed earlier, according to the AD-HOC network combined communication system, the communication apparatus and the communication method of the present invention, when the source and destination mobile terminal devices form the same AD-HOC network, the remarkably economical and stable mobile communication can be performed via relaying mobile terminal devices without exclusively using infrastructure-based fixed communication facilities. On the other hand, the conventional wireless mobile communication can be still used. According to a preferred embodiment of the present invention, when the source mobile terminal device or the destination mobile terminal device exists in the service constrained area such as a radio wave shadowing area or uses different communication system from the infrastructure-based fixed communication facilities, the mobile terminal device can communicate with other mobile terminal devices by using the infrastructure-based fixed communication facilities via the AD-HOC network. According to another preferred embodiment of the present invention, when the mobile terminal device communicates with other mobile terminal devices by using the AD-HOC network, the distributed control communication mode and the centralized control communication mode can be flexibly used according to dynamically changing communication conditions, thereby enabling the effective use of channels.

In addition, according to a preferred embodiment of the present invention, the vertical hand-off between different wireless mobile communication networks is possible by performing communication using the common AD-HOC protocol. According to a preferred embodiment of the present invention, there is provided

the mobile terminal device with which can connect a satellite ground station for communication with a

<Desc/Clms Page number 35>

satellite or VSAT, a bidirectional satellite terminal device with the very small aperture, the wireless mobile communication system, and the mobile communication method.

According to another preferred embodiment of the present invention, the communication system is provided wherein data can be effectively routed between different mobile communication networks by extracting precise location information of a mobile terminal device from a GPS communication signal or a beacon signal received from an adjacent mobile terminal device.

The preferred embodiments of the present inventions have been shown by way of examples. The invention covers all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined in the appended claims.

---